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New data on the distribution of *Rhombodera latipronotum* (Mantodea, Mantidae) in Southeast Asia, with species redescription and biogeographic considerations

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Abstract

This study updates the known distribution of *Rhombodera latipronotum* Zhang, 1990, a mantis species previously documented only in the Yunnan province of China. New findings confirm its presence in the Guangxi autonomous region and the Indo-Chinese states of Laos and Vietnam. The research incorporates both direct analysis of collected specimens and data gathered from citizen-science platforms. These methodologies have allowed for a redefinition of the species' range in Southeast Asia and have provided new insights into its external morphology and intraspecific variability. Due to its recent description and the limited availability of scientific literature, *R. latipronotum* remains poorly understood. This study overcomes these limitations by providing the first detailed description of both sexes, highlighting the intraspecific variability of the specimens, and discussing the potential existence of distinct populations within the species. The research also highlights the immense biodiversity within the surveyed regions, emphasizing the need for extensive exploration to fully catalogue the species of the order Mantodea. Understanding the distribution and ecological roles of these mantids is essential for their conservation. The study's findings contribute to a deeper knowledge of *R. latipronotum* and underscore the importance of continued biological surveys and conservation efforts in these biodiverse yet underexplored areas of Southeast Asia.

Keywords

Citizen science, distribution update, Hierodulini, Indochina, shield mantis

Introduction

Rhombodera Burmeister, 1838 is a genus of praying mantises belonging to the family Mantidae, subfamily Hierodulinae, and tribe Hierodulini. They are known by the common name "Asian shield mantids" because of a feature shared by all species included in this genus: the presence of more or less pronounced lateral pronotal expansions that make the first thoracic segment resemble a shield. In most species, the dorsal part of this shield is green and helps the insect camouflage itself, even hiding its forelimbs when they are folded, while the ventral part is brightly colored, and the insect displays it during the deimatic poses it performs when it has already been spotted by a predator and can no longer resort to cryptic camouflage (Wieland 2013).

Other typical features include straight or only slightly curved vertex, head generally wider than long, well-developed flight organs in both sexes but longer in the male, which can make flights of considerable distances. The tegminae are green or brown, with opaque costal and/or discoidal area having a whitish stigma with or without dark outlines; hind wings are hyaline or partially shaded with bright colors, especially in the costal area. Fore femora with 4 internal and 4 external spines, and claw groove located proximally in the middle of the limb; fore tibiae with 9–11 external spines; metatarsi of the hind legs about as long as the remaining segments put together; supra-anal plate transverse and rounded at the cerci (Ehrmann 2002). The genus currently includes 30 species (Anderson 2024) spread widely in mainland and insular Asia in countries such as Cambodia, China, India, Indonesia, Japan, Laos, Malaysia, Myanmar, Nepal, Papua New Guinea, Philippine Islands, Solomon Islands, Sri Lanka, Thailand, Timor, and Vietnam (Patel and Singh 2016). However, the taxonomy and phylogeny of the Hierodulini are not yet well defined, and synonyms in this large group of mantids are frequently rediscussed and updated, especially between the genera *Hierodula* Burmeister, 1838, *Rhombodera* Burmeister, 1838, *Titanodula* Vermeersch, 2020, and *Sphodromantis* Stål, 1871 (Vermeersch 2020, Vermeersch and Unnahachote 2020). For this reason, it is very likely that the number of species will change again, and some actual members of the genus *Rhombodera* will be transferred into new genera, as happened in the past.

The species *Rhombodera latipronotum* Zhang, 1990 was described in 1990 by Zhang as endemic to southern China, specifically the forested areas of Yunnan province, one of the country's richest places for mantids (and insects in general) and considered an intersection of three different biodiversity hotspots: the Indo-Burma region, the mountains of Southwest China, and the eastern Himalayas region (Yu et al. 2022). The specific epithet *latipronotum* is derived from the union of the Latin adjective *lātus*, *lată*, *latum*, meaning "broad" or "wide," and the noun *pronotum*, which precisely denotes the dorsal

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part of the first thoracic segment of the insects. Indeed, the distinguishing characteristic of this mantis is the width of the pronotum, which is wider than that of many other *Rhombodera* species and sometimes exceeding 20 mm in adult females (Liu et al. 2021). The description of this new species occurred relatively recently, and several authors have pointed out how difficult it is to collect specimens for examination. The discoverer of the species based his original description on a single male specimen designated as the holotype. Subsequently, other mantis enthusiasts attempted to collect specimens of *R. latipronotum* at the type locality using light traps. It was found that only males were attracted to the traps, while females were much more difficult to catch (Xiaoyu 2012).

Due to the aforementioned taxonomic uncertainties, identification of specimens of this species is not always possible, partly due to the often incomplete scientific literature on this insect. In more recent years, the increasing interest in mantids around the world, including their taxonomy and amateur breeding (Battiston et al. 2022), has prompted many citizens to take a critical look at the mantises in their areas, taking photos of them and uploading them to citizen science platforms. Thanks to their fieldwork, scholars have made numerous discoveries about the external morphology of still little-known mantids and that the distributions given in scientific articles do not always correspond to the truth, as they might be obtained from outdated or incomplete data (Battiston et al. 2021). This article aimed to update the geographic distribution of *R. latipronotum* and provide a redescription of its external morphology. The implications of updating *R. latipronotum*'s distribution range, particularly on the mantid fauna of Southeast Asia, are also discussed.

Materials and methods

The study included the collection and examination of specimens kept in entomological collections as well as the observations of citizen scientists from different Southeast Asian countries who uploaded photographs to platforms such as iNaturalist and the Global Biodiversity Information Facility (GBIF) or on social networks. On Facebook, various reports were collected through insect identification groups, and on Instagram, through the creation of the 'Mondo delle Mantidi' (in Italian means "World of Mantids") network, the author of the study was able to collect further reports from ordinary citizens through the chat rooms. For each insect photo, users were asked for the exact location where the specimen was found and relevant environmental information, such as whether the location was urban or suburban. All citizens' reports were compared with specimens in the author's entomological collection, producing, in tandem with photographs taken with a Nikon Coolpix B500 and processed with the Adobe Photoshop program, an accurate description of adults of both sexes. The terminology used follows Brannoch et al. (2017), and the preparation of the genitalia follows Battiston et al. (2010). Distribution maps were made using QGIS 3.34 Prizen software.

Results

Rhombodera latipronotum Zhang, 1990

Material examined.—CHINA • 1 ♀; Guanxi autonomous region, Fangchenggang, Fangcheng district; Banba town; 21°39'48.2"N, 107°43'37.7"E; 69 m.a.s.l.; 16 Nov. 2023; Liangle leg. https://www.iNaturalist.org/observations/191669488; • 2 ♀; Guanxi autonomous region, Fangchenggang, Fangcheng district; Nadong town; 21°40'07.0"N, 107°43'49.0"E; 9 May 2023; Liangle leg. https://www.iNaturalist.org/observations/164873604; • 1 nymph ♀; Guanxi autonomous region, Fangchenggang, Fangcheng district; Nadong town; 21°46'01.0"N, 107°45'48.0"E; 31 Jul. 2023; Manassas leg. https://www.iNaturalist.org/observations/178201482; • 1 ootheca; Guanxi autonomous region, Fangchenggang, Fangcheng district; Dongxing; 21°42'05.0"N, 107°58'20.7"E; 12 m.a.s.l.; 15 May 2021; Manassas leg. https://www.iNaturalist.org/observations/79911245; • 1 nymph ♂; Guanxi autonomous region, Fangchenggang, Fangcheng district; Donxing; 21°41'04.0"N, 107°59'26.0"E; 12 m.a.s.l.; 14 Aug. 2023; Manassas leg. https://www.iNaturalist.org/observations/178570482; LAOS • 1 nymph ♀; Louangphrabang province, Louangphrabang district, Ban Long village; 19°44'59.5"N, 101°59'34.9"E; 305 m.a.s.l.; 12 Nov. 2023; Rudolf Wiborny leg. https://www.iNaturalist.org/observations/206965468; • 1 ♂; Huaphanne province, Phu Phane Mt., 20°12'N, 103°59'E; 1200–1900 m.a.s.l.; 20 May 2014; St. Jackl & Lao collector leg.; A. Fasano personal collection • 1 ♂; Oudomxay province, Xay district, 20°42'41.2"N, 102°06'27.7"E; 4 May 2024; Sun Wen Hao leg. https://www.iNaturalist.org/observations/214106349; VIETNAM • 1 ♂; Đồng Bằng Sông Hồng region, Hà Nội municipality, 21°00'57.1"N, 105°48'15.3"E; 15 m.a.s.l.; 28 Mar. 2021; Will Dinneen leg. https://www.iNaturalist.org/observations/72334078; • 1 ♂; Đông Bắc region, Cao Bang province, Nguyên Bình district, 22°37'41.4"N, 105°54'41.7"E; 14 Apr. 2021; Eugene Popov leg. https://www.iNaturalist.org/observations/74029097; VIETNAM • 1 ♀; Đông Bắc region, Cao Bang province, Trùng Khánh District, Đàm Thuỷ, Đàm Thuỷ; 22°51'13.9"N, 106°43'25.4"E; 03 Jan. 2024; Joshua P. leg. https://www.iNaturalist.org/observations/199881298.

Diagnosis.—Large mantids, characterized by a marked dilatation of the pronotum, which is 16 to over 20 millimeters wide. The hind wings are hyaline and lack the reddish tinge typical of many other species of the genus *Rhombodera*.

Male. (Fig. 1) Large with uniform green coloring. Head triangular with a vertex almost without relief, only slightly protruding, with an ocellar tubercle housing three large, well-developed, triangularly arranged ocelli. Postclypeus trapezoidal with well-defined raised contours, superior margin forming an obtuse angle, and two central ribbon-like protuberances of light color crossing it longitudinally. Compound eyes well developed, globular, and slightly protruding laterally. Postclypeus broader than high, separated from the clypeus by a well-defined epistomal groove with a small central protuberance, upper margin slightly arched. Labrum trapezoidal, slightly higher than clypeus and slightly darker in color. Palpi conspicuous and only slightly pubescent. Antennae filiform with coloration similar to that of the body from the base to the first antennomeres, gradually darkening distally. Pronotum robust, with a marked supracoxal dilatation, semicircular in shape, well-shaped and with a smooth margin without denticles, the metazone two and a half times as long as the prozone; the superior margin has an expansion that dorsally hides part of the head; the inferior margin has a narrow and truncate extremity, longitudinal median carina well evident. Prothoracic legs with evenly green coxae and some yellowish shades on the inner side with 7–9 whitish marginal spines, moderately long and thin. Slightly protruding trochanter of dark coloration. Femora with slightly curved green upper margin, yellowish inner side with several brown areas at the discoidal spines and the row of anteroventral inner spines. Discoidal spines long and black except at the base, 13–15 anteroventral spines unequal in length and coloration, arranged as follows: IiiIiIiIiIi. Longer spines completely black with brown blotch at base; smaller spines same color as inner side of femur except for the tip, which is black.

Claw groove very evident, forming a depression on the femur of a light color. Tibiae yellowish, with 14–15 internal spines and 11 external spines, all black only at the tip. Tarsi well-developed, with basitarsus as long as all tarsomeres put together; well-developed euplantulae with adherent ends useful for clinging to plants. Meso- and metathoracic legs uniformly green, simple, and lobeless, with no evident genicular spurs and two tibial spurs. Abdomen narrow, tapering, uniformly green on tergites and sternites, with reddish hues on pleura. Dark spots between the third and fifth sternites, used by the insect in deimatic displays. The subgenital plate is trapezoidal in shape, with relatively long styli. Cerci well developed, whitish proximally and darker distally, and covered with fine hair. Wings well developed and functional, exceeding the length of the abdomen. Forewings with green costal area, stigma whitish with milky appearance and partly surrounded by dark brown halo, veins jagged and irregular. Hind wings with slight green coloration only on superior margin, rest of wing surface colorless, with no reddish tinge or wing spots. Genital with apical process of left phallomere (paa) long, with hook-like apex. Anterior lobe of phalloid apophysis (aafa) contorted, posterior lobe of phalloid apophysis (pafa) short, not beyond the posteromesal of left phallomere (loa). Both aafa and pafa quite sharp apically. Lateral secondary distal process (sdpl) of ventral phallomere uniformly bending, rod-like and gradually narrowing, and apically sharp. Right phallomere with posterior main lobe (fda) nearly triangular, pva and pia claw-like.

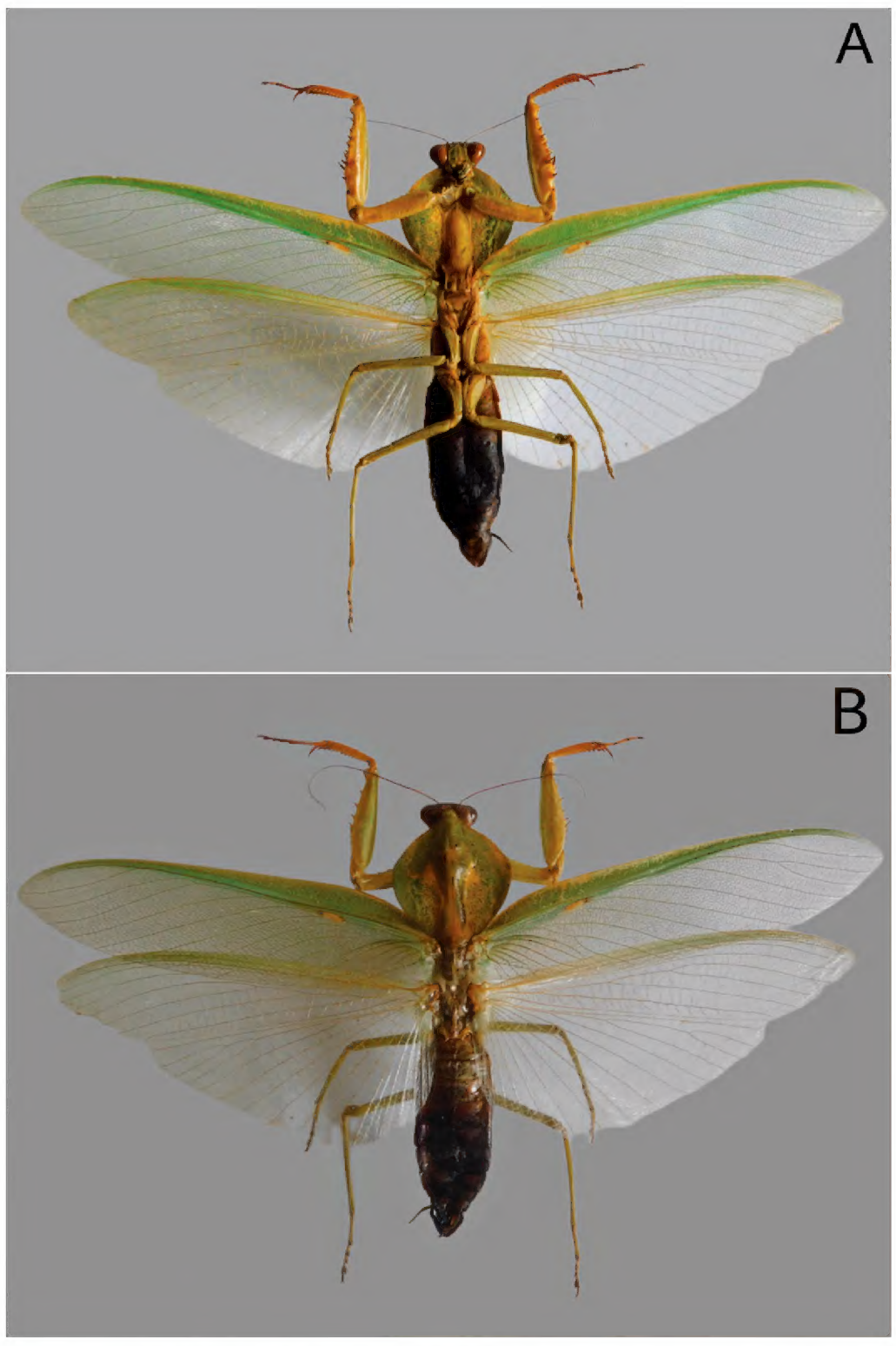

Fig. 1. *Rhombodera latipronotum*: Adult male from Huaphanne province, northeastern Laos. **A.** Ventral view; **B.** Dorsal view.

Female. Very large and robust-looking, body coloration uniformly green with aquamarine highlights, reddish spots on the lower part of abdomen, mesothorax, and metathorax. Robust, triangular head, the top of which is smooth, lacking protuberances or depressions. Compound eyes large, globular, and slightly protruding. Ocelli small and less prominent than in males. Postclypeus pentagonal, taller than wide, separated from the clypeus by an evident epistomal groove, with two fairings running its entire length. Postclypeus trapezoidal, uniformly colored. Labrum trapezoidal, with the inferior margin rounded and yellowish. Mandibles highly developed, with the tip colored dark. Palpi elongated with low pubescence. Antennae filiform, with pedicel and scape the same color as the head, and dark antennomeres. Pronotum very robust, with large, almost semicircular lateral expansions that entirely occlude dorsal view of forelegs. Edges of expansions are rounded and free of irregularities; metazona approximately two and a half times longer than prozone, the supracoxal groove very evident. On the ventral side, coloration of pronotum less uniform and tends to have irregularities, with several jagged areas of yellow or whitish. Prothoracic legs with green coxae, some yellowish shades on inner side, with 8–10 whitish marginal spines quite long and wide. Slightly protruding trochanter of dark coloration. Femora with slightly curved green upper margin, yellowish inner side with several brown areas at the discoidal spines and row of anteroventral inner spines. Discoidal spines long and black except at base, 13–15 anteroventral spines unequal in length and coloration, arranged as follows: IiiIiIiIiIiI. Longer spines completely black with brown blotch at base, smaller spines same color as inner side of femur except for tip, which is black. Claw groove very evident, forming a depression on femur in light color. Tibiae yellowish, with 14–15 internal spines and 11 external spines, all black only at tip. Tarsi well-developed, with basitarsus as long as rest of tarsomeres put together; well-developed euplantulae with adherent ends useful for clinging to plants. Meso- and metathoracic legs uniformly green, simple, and lobe-less, with no evident genicular spurs and two tibial spurs. Abdomen narrow, tapering, uniformly green on tergites and sternites, with reddish hues on pleura and stigmas. Dark spots between third and fifth sternites, used by the insect in deimatic displays. Well-developed, yellowish cerci covered with fine hairs. Wings fully developed, reaching end of abdomen. Forewings uniformly green with bright white stigma with dark brown outlines . Hind wings with uniform coloration except for the upper margin of costal area edged with green.

Measurements.—(In mm.) ♂ (n = 2), ♀ (n = 1). Total length ♂ 72.5–82.3, ♀ 89.3. Pronotum length ♂ 20.5–21.0, ♀ 23.1. Pronotum width ♂ 17.5–17.7, ♀ 22.2. Forewing length ♂ 60.6–61.2, ♀ 54.6.

Distributional and ethological remarks.—The range of the species expands southeast from the type locality where it was originally described (Fig. 2). Its presence is now confirmed in the Chinese autonomous region of Guanxi, Laos, and Vietnam (Fig. 3). All new territories where *R. latipronotum* has been reported also belong to the Indo-Malay ecozone, characterized by recurrent tropical biomes such as rainforests, seasonal forests, and grasslands. The climate is largely influenced by alternations between trade winds and monsoon seasons (Goodall 1977). From the observations collected, it was established that this mantis can be found in both lowland areas and on elevations, in both cases in areas with a high density of tree, shrub, and grass vegetation. Females remain flattened on leaves, waiting for prey and laying oothecae on branches even several me-

ters above the ground, while males are easily attracted to artificial lights and, because of their greater flying skills, able to move long distances. As is the case in the type locality (southern Yunnan), this species is not abundant in the areas where it is encountered, remaining fairly confined and thus common only locally (Wu 2021).

Morphological remarks.—The original description of this species by Zhang in 1990 is based on the unspecified primary type, whose sex is unknown. The description of the type specimen is sketchy, lacking specifics on certain body parts such as the head, abdomen, wings (except the stigma), and middle and hind legs.

Discussion

The report of *R. latipronotum* in new Asian localities represents a significant advancement in the field of biogeography and in the taxonomy of praying mantids. This discovery expands our understanding of the geographical distribution of this species, suggesting that it has a wider habitat range and greater adaptability than previously thought. Reports of *R. latipronotum* in new regions such as Laos, Vietnam, and Guangxi indicate that this mantis species is capable of adapting to a variety of environments, from the tropical climate of Southeast Asia to the specific conditions of the Guangxi

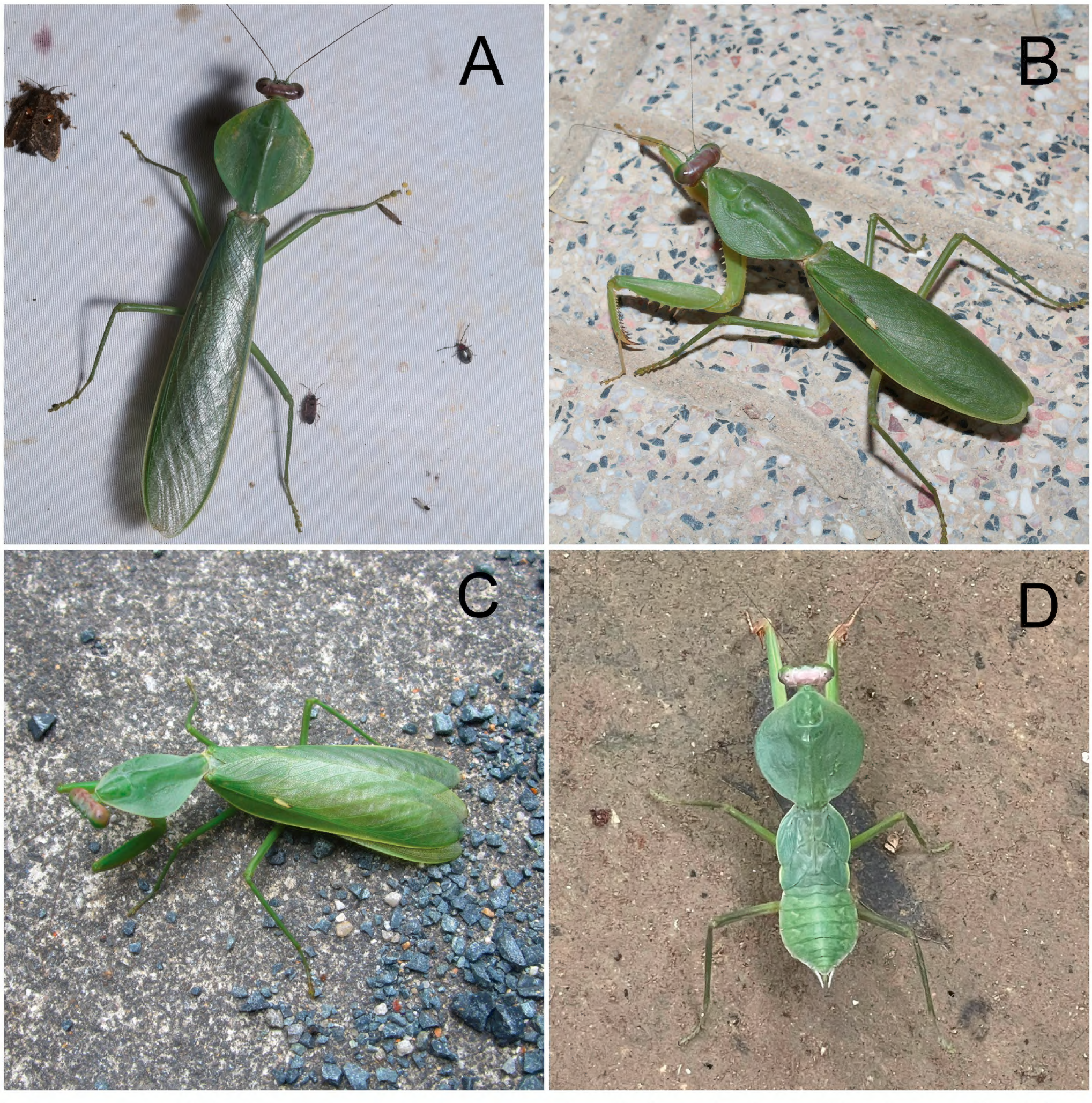

Fig. 2. Images of several *Rhombodera latipronotum* specimens reported outside the type locality. **A.** Adult male attracted by a light trap from a tropical forest in Oudomxay province, Laos. Photo by Sun Wen Hao. **B.** Adult female from Cao Bang, Vietnam. Photo by Joshua P. **C.** Adult male from Fangcheng district, Guanxi, China. Photo by Manassas. **D.** Female nymph from Luang Prabang waterfall, Laos. Note the very prominent pronotal expansion. Photo by Rudolf Wiborny.

region in China. This suggests that it possesses considerable ecological plasticity, allowing it to colonize a variety of ecological niches.

The ability of *R. latipronotum* to colonize new habitats demonstrates considerable ecological adaptability. This species is able to exploit a wide range of food resources and adapt to different microhabitats. Future ecological studies should focus on analyzing the specific environmental requirements of the species and the adaptation strategies that allow it to thrive in different environments. The introduction of this species into new ecosystems can influence the dynamics of local insect communities; being an efficient predator, its presence could alter prey populations and compete with other predators. Thus, it is essential to study the ecological interactions of *R. latipronotum* with other species to understand the ecological impact of its geographic expansion. Additionally, the possibility that the species' expansion is partly due to accidental or deliberate introductions by humans cannot be ruled out given the increasing movement of goods and people between these regions (Battiston et al. 2018; Battiston et al. 2020).

The new populations of *R. latipronotum* in Laos, Vietnam, and Guangxi also require special attention for conservation (Wikramanayake et al. 2002). If these populations are found in threatened or fragmented habitats, they may require specific protection measures. Knowledge of the extensive distribution of the species may inform more targeted and effective conservation strategies, ensuring the protection of critical habitats and vulnerable populations.

Similarly, the new reports of *R. Latipronotum* provide valuable insights for biogeographical research (Zhou and Shen 1992). The presence of the species in different regions may suggest ancient connections between now-disjointed habitats or processes of natural dispersion. Future studies should investigate the mechanisms of this species' dispersion, including the biotic and abiotic factors that promote its spread and stabilization in new territories. Understanding the evolutionary history and dispersion patterns of *R. latipronotum* can be deepened through comparative studies with other species of the genus *Rhombodera*. This could reveal information about dispersion modes, such as migration through ecological corridors or colonization of new habitats in response to climate and environmental changes.

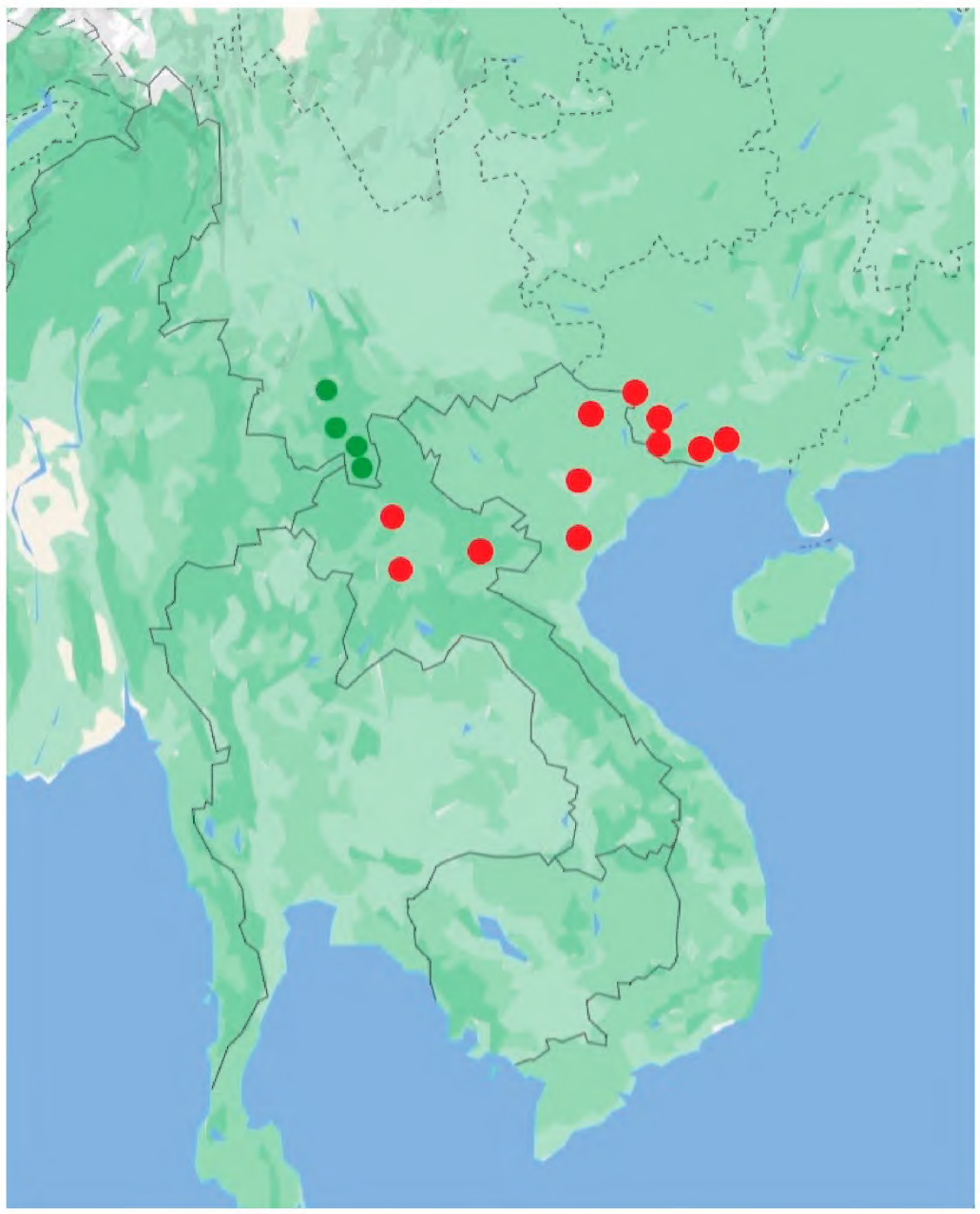

Fig. 3. Updated map of the distribution of *Rhombodera latipronotum*. Green dots indicate type localities and previous sightings for this species; red dots indicate new reports discussed in this article. Base image from Google Maps 2024 © Google.

The results of this study represent a significant expansion of our knowledge of the distribution of this species, highlighting the importance of continuing exploration and documentation of biodiversity, especially in poorly known regions. The presence of the species in new habitats underscores the dynamic nature of biodiversity and the need for continuous monitoring to adapt conservation and species management strategies. The expansion of the geographical distribution of *R. latipronotum* offers new opportunities for ecological and biogeographical research, contributing to a better understanding of ecological interactions and evolutionary dynamics. Future studies should focus on a detailed analysis of the ecological requirements of the species, its interactions with other species, and implications for conservation, ensuring the protection and sustainability of *R. latipronotum* populations throughout its new geographical range.

In this study, the descriptions and morphological knowledge of *R. latipronotum* were updated, expanding our understanding of this species within the *Rhombodera* genus. Previously undescribed morphological features, such as the structure of the forewings and the presence of intraspecific variability of the pronotum, were revealed. These observations further distinguish *R. latipronotum* from congeneric species and provide new insights for the taxonomic revision of the group. Additionally, the integration of advanced imaging techniques allowed us to document key morphological structures with greater precision, offering a detailed reference for future comparative studies. These findings both enrich the morphological description of this species and suggest the need for a reassessment of phylogenetic relationships within the genus, highlighting the importance of detailed morphological analysis for accurate species identification.

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The author declares that they have no conflict of interest.

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